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IS 14774-1 (2000): Resistance Trace Heating in Potentially Explosive Atmospheres, Part 1: General and Testing Requirements [ETD 22: Electrical Apparatus for Explosive Atmosphere]

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संभावित विस्फोटक वातावरण में विद्युत प्रतिरोधी ट्रेस तापन

भाग 1 सामान्य एवं परीक्षण अपेक्षाएँ

Indian Standard

ELECTRICAL RESISTANCE TRACE HEATING IN POTENTIALLY EXPLOSIVE ATMOSPHERES

PART 1 GENERAL AND TESTING REQUIREMENTS

ICS 19.020;29.260.20

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Price Group 7

Electrical Apparatus for Explosive Atmospheres Sectional Committee, ETD 22

FOREWORD

This Indian Standard was adopted by Bureau of Indian Standards, after the draft finalized by the Electrical Apparatus for Explosive Atmospheres Sectional Committee had been approved by the Electrotechnical Division Council.

This standard (Part 1) is one of the series of Indian Standards which deals with electrical resistance trace heating in potentially explosive atmospheres. The series comprises of the following two parts:

Part 1 General and testing requirements

Part 2 Informative application guide for design installation and maintenance

This standard (Part 1) covers the general and testing requirements for electrical resistance trace heating in potentially explosive atmospheres.

In the preparation of this standard assistance has been derived from Doc : 31/292/CDV circulated by the International Electrotechnical Commission (IEC).

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTRICAL RESISTANCE TRACE HEATING IN POTENTIALLY EXPLOSIVE ATMOSPHERES

PART 1 GENERAL AND TESTING REQUIREMENTS

1 SCOPE

This standard (Part 1) specifies requirements and test methods for electrical resistance heaters for application in potentially explosive atmospheres.

The standard covers trace heaters that may either be factory or field (work site) assembled units, and which may be series heating cables, parallel heating cables, heating pads and heating panels that have been assembled and/or terminated in accordance with manufacturer's instructions.

This standard also includes requirements for termination assemblies and control method used with trace heating. Requirements are given for potentially explosive areas, as defined in IS 5571.

2 REFERENCES

The referred Indian Standards are given in Annex A.

3 DEFINITIONS

In addition to the definitions given in IS 5571, the following definitions shall apply.

3.1 Ambient Temperature

The temperature surrounding the object under consideration. Where electrical trace heaters are enclosed in thermal insulation, the ambient temperature is the temperature exterior to such thermal insulation.

3.2 Branch Circuit

The portion of the wiring installation between the over-current device protecting the circuit and the trace heater unit(s).

3.3 Certifying Body

Organization that validates and certifies equipment meeting the requirements of particular standards.

3.4 Connection/Terminations

3.4.1 *Cold Lead*

An electrically insulated conductor or conductors used to connect a trace heater to the branch circuit and designed so that it does not produce significant heat.

3.4.2 *End Termination*

A termination, which may be heat producing, applied to a trace heater at the end opposite that where the power is supplied.

3.4.3 *In-Line Connection*

Electrical connection of two trace heaters, in series or in parallel.

3.4.4 *Power Termination*

The termination applied to the end of a trace heater at which the power is supplied.

3.4.5 *Tee*

Electrical connection of trace heaters, in series or in parallel, to accommodate a tee or branch.

3.5 Corrosion Resistant Covering

A continuous layer of insulating material applied outside the metallic sheath, screen or armouring to protect against corosion.

3.6 Dead Leg

A segment of process piping segregated from the normal pattern for the purpose of providing a heat loss reference.

3.7 Design Loading

The minimum power that will meet the design requirements, in the worst conditions, after voltage and resistance tolerances and appropriate safety have been considered.

3.8 Factory Fabricated

A trace heating cable, tape or device, including the necessary terminations and connections, which is assembled into units or sets.

3.9 Field Assembled

Trace heaters supplied in bulk with terminating components to be assembled at the work site.

3.10 Heat Loss

Energy flow from a pipe, vessel or equipment to its surroundings.

3.11 Heat Sink

A part that conducts and dissipates heat away from a workpiece. Heat sinks are, typically, pipe shoes, pipe supports and items of large mass such as valve actuators or pump bodies.

3.12 Heat-Transfer Aids

Thermally conductive materials, such as metallic foils or heat transfer cements which are used to increase the heat-transfer efficiency from trace heaters to the workpiece.

3.13 Heating Pad

A trace heater comprising series or parallel connected elements having sufficient flexibility to conform to the shape of the surface to be heated.

3.14 Heating Panel

A non-flexible trace heater comprising series or parallel connected elements fabricated to conform to the general shape of the surface to be heated.

3.15 High Limit Temperature

The maximum allowable temperature of the system, including the piping, the fluid and the heating system.

3.16 Limiting Trace Heater Temperature

The maximum permissible continuous temperature of the trace heater.

3.17 Maintain Temperature

Specified temperature of the fluid or process material which the trace heating system is designed to maintain under specified conditions.

3.18 Maximum Ambient Temperature

The highest ambient temperature at which the trace heating shall be operable and should perform according to specified requirements.

3.19 Maximum Continuous Exposure Temperature

The highest temperature to which the trace heating system may be exposed.

3.20 Maximum Intermittent Exposure Temperature

The maximum temperature of any surface adjacent to the trace heater, which the energized trace heater can withstand for specified period.

3.21 Maximum Withstand Temperature

The maximum operating or exposure temperature that will not adversely effect the thermal stability of the heater and its component parts.

3.22 Metallic Covering

A metal sheath or braid used to provide physical protection for a trace heater, and/or an electrical earth/ground path.

3.23 Maximum Ambient Temperature

The lowest ambient temperature specified at which the trace heating shall be operable and shall perform according to specified requirements and on which heat loss calculations will be based.

3.24 Minimum Installation Temperature

The minimum temperature at which a trace heater may be installed.

3.25 Operating Voltage

The actual voltage applied to the trace heater when it is in service.

3.26 Overjacket

A final covering continuously applied over the metallic braid or armour of a trace heater typically used for mechanical and/or corrosion protection.

3.27 Parallel Trace Heater(s)

Heating elements that are electrially connected in parallel, either continuously or in separate zones.

3.28 Power Density

The power output in watts per linear metre for trace heater cable and cable units, and in watts per square metre for trace heater pads and panel and trace heater pad and panel units.

3.29 Rated Output

Total power or power per unit length of heating cable or trace heater, at rated voltage, temperature and length which is normally expressed in watts/m or watts/m^2.

3.30 Rated Voltage

The voltage to which operating and performance characteristics of trace heaters is referred.

3.31 Routine Test

A test that is carried out by the manufacturer prior to shipment to verify conformity with the manufacturer's specification.

3.32 Series Trace Heater(s)

Heating elements that are electrically connected in series with a single current path and have a specific resistance at a given temperature for a given length.

3.33 Sheath

A uniform and continuous metallic or non-metallic outer covering enclosing the heating tape or cable used to provide protection for the cable against influence from the surroundings (corrosion, moisture etc) (*see* over-jacket).

3.34 Sheath Temperature

The temperature of the outermost continuous covering that may be exposed to the surrounding atmosphere.

3.35 Stabilized Design

A concept where the temperature of the trace heater will, by design and use, stabilize below the limiting temperature, under the most unfavourable conditions, without the need for a protective system to limit the temperature.

3.36 Start-Up Current

The current of a trace heater immediately upon energizing.

3.37 System Documentation

Information provided by the supplier to allow satisfactory understanding, installation and safe use of the trace heating system.

3.38 Temperature Controller

A device or combination of devices incorporating a means of sensing temperature and of controlling the power to the trace heater.

3.39 Temperature Sensor; Sensing Element

A device which is designed to respond to temperature providing an electrical signal or mechanical operation.

3.40 Thermal Insulation

Material having air or gas filled pocket,void spaces, or heat reflecting surfaces that, when properly applied, will retard the transfer of heat.

3.41 Trace Heater

A device designed for the purpose of producing heat on the principle of electrical resistance and typically composed of one or more metallic conductors or an electrically conductive material, suitably electrically insulated and protected.

3.42 Trace Heater Unit; Trace Heater Set

A series trace heater cable, parallel trace heater cable, heater pad or heater panel suitably terminated in conformity with the manufacturer's instructions.

3.43 Trace Heating

The utilization of electric trace heater cable, pads, panels and support components that are externally applied and used to raise or maintain the temperature of contents in piping, tanks and associated equipment.

3.44 Type Test

A test or series of tests carried out on trace heating cables, tapes, devices and associated accessories, which the representative of a type, to determine conformity of the design, construction and manufacturing methods to the requirements of this standard.

3.45 Weather Barrier

Material that, when installed on the outer surface of thermal insulation, protects the thermal insulation from water or other liquids, from physical damage caused by sleet, wind or mechanical abuse, and deterioration caused by solar radiation or atmospheric contamination.

3.46 Workpiece

Objects to be heated by a trace heater which includes, for example, process equipment such as piping, vessels, tanks, valves, instruments and similar equipment.

4 GENERAL REQUIREMENTS

4.1 General

Electrical resistance trace heating within the scope of this standard shall be designed and constructed so as to ensure electrical, thermal and mechanical durability, and reliable performance such that in normal use it poses no danger to the user or the surroundings. Electrical resistance trace heaters and terminations shall comply with one or more of the standardized types of protection listed in IS 5571 and additionally with the requirements of this standard.

The manufacturer shall declare the maximum operating temperature in °C. The materials used in the trace heater withstand a temperature of the maximum operating temperature +20 K, when tested in accordance with **5.1.11**.

For the purpose of this standard resistance trace heaters are not considered to be windings.

4.2 Trace Heaters

Trace heaters shall be provided with a metallic braid or metallic sheath which shall cover at least 70 percent of the surface. They shall be capable of withstanding an impact load of 7 J or 3.5 J when tested in accordance with **5.1.5**. For the 3.5 J impact load, heater shall be marked with the symbol 'X'.

4.3 Terminations and Connections

Terminations and connections may be identified as an integral part of a trace heater, or may be identified separately, in which case they are regarded as Ex components in accordance with IS 5571. They are tested as part of a representative trace heater unit (*see* **5.1.1**).

4.4 Circuit Protection Requirements for Branch Circuits

The minimum requirements for trace heating systems for use in hazardous areas are:

a) a means of isolating the circuit from the supply;
b) over-current protection provided for each branch circuit; and
c) earth fault protection for each branch circuit.

4.5 Control and Temperature Requirements

4.5.1 *General*

A trace heating system shall be designed so that under all conditions that may reasonably be foreseen, the surface temperature of the trace heaters is limited to the temperature classification or ignition temperature or lower. This shall be achieved either by a stabilized design in accordance with **4.5.2**, or the use of temperature control devices in accordance with **4.5.3** to limit the maximum equipment temperature.

When multiple trace heaters (especially on pipes with different flow conditions) are grouped together under a single surface-sensing temperature control device, each one shall be analysed as a stabilized pipe design.

4.5.2 *Stabilised Design for Zone 1 and Zone 2 Applications*

Stabilized designs — These are applications where the maximum surface temperature of the heating device is determined without thermostatic control. Two approaches are used:

a) A product classification approach, in which the maximum self-generated sheath temperature of the heating device has been established by testing the device in an artifical environment simulating worst-case conditions.

b) A system approach in which the manufacturer has demonstrated the ability to predict sheath temperature by conducting tests. Use 40°C maximum ambient, unless a higher ambient is specified.

Stabilized design applications, in which the maximum surface temperature of the trace heater is determined without thermostatic control, shall employ either the systems approach specified in **5.1.11.2** or the product classification approach specified in **5.1.11.3**.

4.5.3 *Controlled Design*

At present this design is not permitted in hazardous area.

Controlled design applications, which require the use of a temperature control device to limit the maximum pipe temperature, shall employ either of the following:

a) *For Zone 1 or Zone 2 application*

Controlled design applications, which require the use of a temperature control device to limit the maximum surface temperature, shall utilize a protective device that will de-energize the system permanently after exceeding the maximum operating temperature. A reset shall only be possible by hand after the previously defined process conditions have returned. In case of an error/damage of the sensor, the heating system shall be de-energized before replacing the defective equipment. The adjustment of the protective device shall be secured and sealed to avoid manipulation. The protective device shall operate independently from the temperature monitoring system.

b) *For Zone 2 applications*

A single temperature controller with failure annunciation. Provision of adequate monitoring of such annunciation, such as 24 h surveillance, shall be made.

5 TESTING

5.1 Type Tests

5.1.1 *General*

The prototype or sample shall be tested by the testing station in accordance with the requirements for type tests of this standard and of the specific standards for the types of protection concerned. However, the testing station:

- may omit certain tests judged to be unnecessary. The testing station shall keep a record for all tests carried out and the justification for those omitted;
- shall not make the tests which have already been carried on an Ex component.

The test shall be made either in the laboratory of the testing station or, subject to agreement between the testing station and the manufacturer, elsewhere under the supervision of the testing station, for example, at the manufacturer's works.

The testing station, where necessary, shall call for modifications that it considers to be needed to bring the electrical apparatus into conformity with this standard and with the specific standards for the types of protection concerned.

Sample of trace heaters at least 3 m in length, unless otherwise specified, shall be selected for testing. Tests shall be conducted at a room temperature between 10°C and 40°C unless otherwise stated. Terminations and connections that are to be installed as an integral part of the trace heater, whether intended to be factory fabricated or field assembled, shall be subjected to the same tests as the trace heater except where otherwise noted. These connections shall include end terminations, tees, in line splices and power terminations, as well as glands, fittings and seals where a heating cable enters a terminations enclosure.

5.1.2 *Dielectric Test*

The dielectric test shall be performed on trace heaters in accordance with Table 1.

Table 1 Test Voltage for the Dielectric Test

Sl No.	Rated Voltage	Test Voltage V ac rms
1)	(2)	(3)
i)	< 30 V rms	500
ii)	< 60 V dc	500
iii)	≥ 30 V rms	$\sqrt{2E} + 1\ 000$
iv)	≥ 60 V dc	$\sqrt{2E} + 1\ 000$

The test voltage where E is the rated voltage shall be applied at a rate of rise neither less than 100 V/s nor more than 200 V/s and maintained for 1 min without dielectric breakdown. The test voltage waveform shall be essentially sinusoidal, with a frequency of 45 Hz to 65 Hz.

5.1.3 *Electrical Insulation Resistance Test*

The electrical insulation resistance shall be measured on the test sample(s) prepared in accordance with **5.1.1** after the dielectric test specified in **5.1.2**. The resistance of the electrical insulation shall be measured between conductors and the metallic outer covering, or a specially applied conductive metal tape or braid, by means of a dc voltage of 1 000 V for mineral insulated heaters and 2 500 V for polymer insulated heaters. The measured value shall be not less than 50 MΩ.

5.1.4 *Flammability Test*

A flammability test shall be performed on trace heaters. The test shall be made in a room free from draughts. The sample trace at least 450 mm in length shall be supported in a vertical position. For pads, panels and other trace heaters the sample width shall be 80 mm.

A gummed kraft paper indicator shall be wrapped once around the sample so that it projects 20 mm from the sample. The paper indicator shall be positioned 250 mm above the point at which the inner blue cone of the flame contacts the sample. A layer of dry, untreated surgical cotton not more than 6 mm in depth shall be placed underneath the sample so that the distance from the cotton to the point of the flame aplication is 250 mm.

The height of the natural gas flame of the burner shall be adjusted to 130 mm with an inner blue cone 4 cm high, as shown in Fig. 1(a). The burner shall be tilted to an angle of 20° from the vertical and the flame applied to the cable so that the tip of the inner blue cone of the flame touches the specimen at the point approximately 150 mm above its lower end. The flame shall be brought up to the trace heater in such a manner that the vertical plane containing the major axis of the burner tube is at right angles to the plane of the cable being tested as shown in Fig. 1(b). The flame shall be applied for 15 s, then removed for 15 s, until five such applications have been made.

The test results shall be considered satisfactory if the heater does not support combustion for more than 1 min after the fifth application of the flame, does not burn more than 25 percent of the extended kraft paper and does not ignite the cotton with falling burning particles.

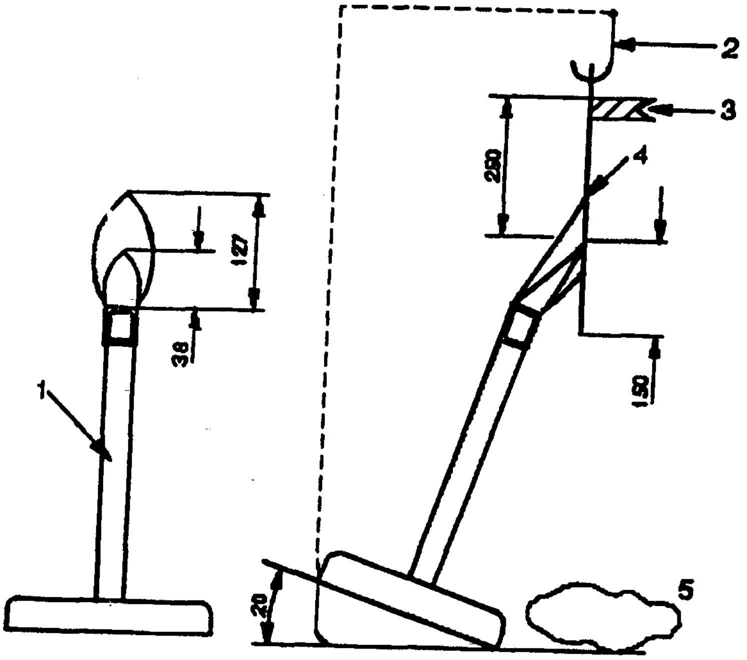
5.1.5 *Impact Test*

NOTE — Electric trace heaters are, in the majority of applications, covered by thermal insulation and therefore afforded some mechanical protection. In some applications, however trace heaters may be installed under conditions where they will not always be protected by thermal insulation; for example, during installation before the thermal insulation is applied or where the trace heater exists from the thermal insulation into a junction box.

The impact test shall be carried out on a sample approximately 20 cm in length Type A. The sample is placed on a rigid flat steel plate and positioned underneath an intermediate piece of hardened steel in the shape of a horizontal cylinder with a diameter of 25 mm. This cylinder is required to have a length of 25 mm with smooth rounded edges to a radius of approximately 5 mm when used to test heating pads and heating panels (*see* Fig. 2). For the test, the cylinder is laid horizontally on the sample and, in the case of a trace heating cable, its axis is placed across the sample. A trace heating cable having a non-circular cross-section shall be so positioned that the impact is applied along the minor axis i.e. trace heating cable is positioned flat on the steel plate).

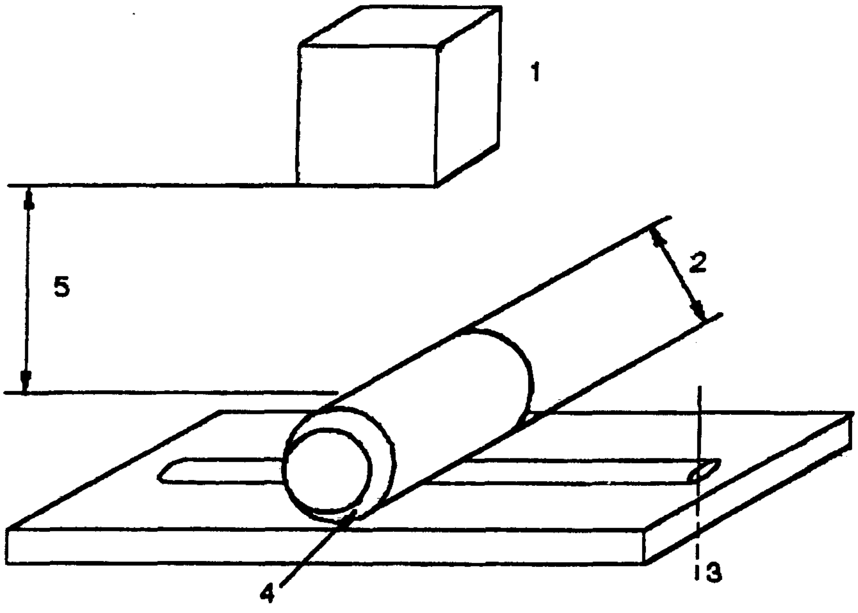
Other than in tests on electrical trace heating intended for use in applications with low risk of mechanical damage, a hammer with a mass of 1 kg shall be allowed to fall once onto the horizontal cylinder from a height of 0.7 m (i.e with an impact load of 7 J).

For trace heating intended for use in applications with low risk of mechanical damage in accordance with **4.2**, the height may be reduced to 0.35 m (that is an impact load of 3.5 J). Electrical resistance trace heating



1 Burner
2 Support
3 Kraft paper flag
4 Test sample
5 Cotton

FIG. 1 FLAMMABILITY TEST



1 Hammer with mass of 1 kg
2 Cylinder with diameter of 25 mm
3 Minor axis of non-circular heating cable
4 Cylinder with 25 mm overall length and 5 mm radius rounding when used to test heating pads and heating panels
5 Height of fall of hammer, 0.7 m or 0.4 m

FIG. 2 IMPACT TEST

submitted to such a test shall be clearly marked with the symbol 'X' in addition to the marking requirements in **6**, to caution the user of its reduced mechanical capability.

Conformity is vertified by testing the electrical insulation in accordance with **5.1.2** and **5.1.3** while the steel cylinder and hammer are still in place on the sample.

5.1.6 *Deformation Test*

A sample is placed on a rigid flat steel plate. A crushing force of 1 500 N is then applied for 30 s, without shock, by means of a 6 mm diameter steel rod with hemispherical ends and a total length of 25 mm for the test, the rod is laid flat on the sample and in case of a trace heating cable it is placed across a specimen at right angles. In the case of a pad, it is necessary to ensure that the cylinder rests across the active element.

The impact test shall be conducted approx – 20 cm in length. Prior to testing the sample, assembly shall be conditioned for a minimum of 4 h at the manufacturer's minimum recommended installation temperature. After conditioning while still at the minimum recomended installation temperature, the sample shall be subjected to the impact forces. Conformity is verfied by testing the electrical insulation in accordance with **5.1.2** and **5.1.3**. While the horizontal steel rod is still in place on the sample and the load applied.

NOTE — Trace heating cable samples need only be approximately 200 mm in length.

5.1.7 *Cold Bend Test*

The test apparatus to be used for the cold bend test is shown in Fig. 3. The test apparatus, with sample in position, is maintained for a period of 4 h between – 25°C and – 30°C or at the manufacturer's minimum declared installed temperature. Immediately afterwords, the sample is bent through 90° around one of the mandrels, then bent through 180° in the opposite direction over the second mandrel and then straightened to its original position. This bending cycle is carried out twice.

Conformity is verified by testing the electrical insulation in accordance with **5.1.2** and **5.1.3**.

NOTE — The system documentation proved by the manufacturer should state all constraints and precautions to be taken and the minimum permissible values of the bending radius.

5.1.8 *Moisture Resistance Test (Trace Heating Cables Only)*

A sample of trace heating cable at least 3 m in length including terminations shall be placed in a water flow and drain apparatus as shown in Fig. 4. The rate of water flow shall be regulated to cover the heating cable and terminations completely for a period of at least 30 s every 5 min, after which it is drained off. The voltage to the water flow solenoid and the voltage applied to the heating cable shall be controlled by a cam switch or equivalent means. The timing sequences shall be such that the heating cable shall be energized for 30 s after the water has been drained. The test shall be continued for a period of 24 h.

At the end of the test period, the sample shall be tested in accordance with **5.1.2**. The end termination shall be inspected to verify that no water ingress has occurred.

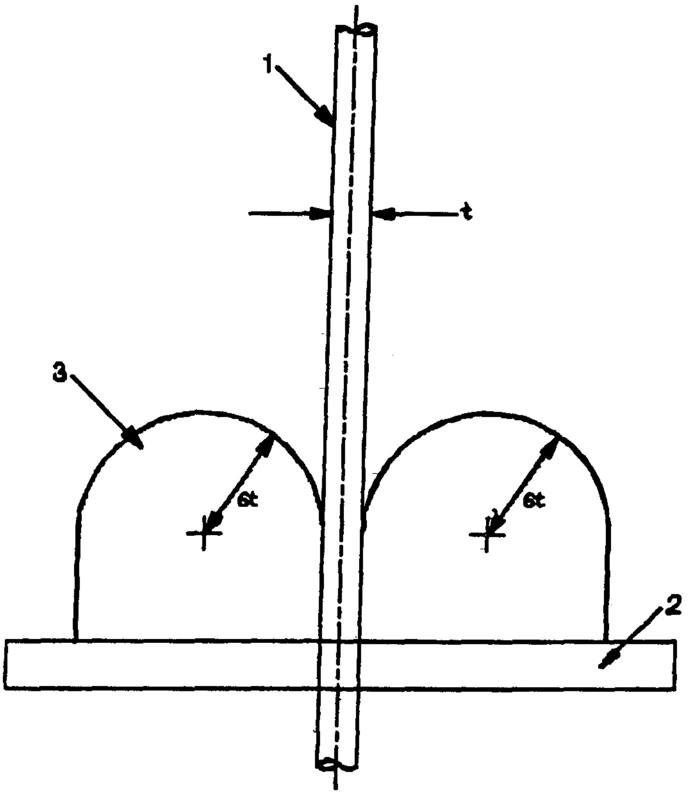
5.1.9 *Verification of Rated Output*

The rated output of the heating cable or heating panel or pad shall be verified by one of the two following methods, as selected by the manufacturer:

a) *Resistance* — The measured dc resistance per unit length at a specified temperature shall by within the manufacturer's declared tolerance.

b) *Thermal* — The thermal output of trace heating cables is measured by installation of a single sample of heating cable, 3 to 6 m in length, on a carbon steel pipe of 50 mm diameter or greater, as shown in Fig. 5. The cable is installed in accordance with the manufacturer's instructions. The test apparatus is completely covered with thermal insulation of 25 mm thickness. For heating pads or panels, the test is conducted on a liquid-cooled flat metal plate with 25 mm of thermal insulation installed over the surface of the heating pad or panel.

A suitable heat transfer liquid is circulated through the pipe at a sufficient rate to establish turbulant flow corresponding to a Reynolds number greater than 2300. This will establish negligible temperature difference between the fluid and the pipe temperature. The heat transfer fluid is maintained at a constant temperature. These parameters are verified by thermocopules placed at the entry and exit ends of the pipe. Flow velocity shall be such that the fluid temperature does not differ by more than 2 K from end to end. The thermal output of the heating cable is measured at three pipe temperatures representative of the full operating range. The heating cable is powered at its rated voltage and allowed to attain equilibrium. The voltage, current and liquid temperatures, and sample length are recorded at each test temperature. Three separate determinations are made on separate samples. The resulting values shall be within the manufacturer's declared tolerance.



1 Sample heating cable
2 Steel base
3 Steel mandrel

FIG. 3 COLD BEND TEST : TYPE TEST

5.1.10 *Thermal Stability of Electrical Insulating Material*

The thermal stability of the electrical insulating materials of trace heaters shall be verified on a sample or prototype after it has been stored at a temperature of the manufacturer's declared operating temperature +20 K, but not less than 80°C for at least 4 weeks. Compliance of the sample or prototype shall be verified by submitting it to the electrical insulation integrity test of **5.1.2**.

5.1.11 *Determination of Maximum Sheath Temperature*

5.1.11.1 *General*

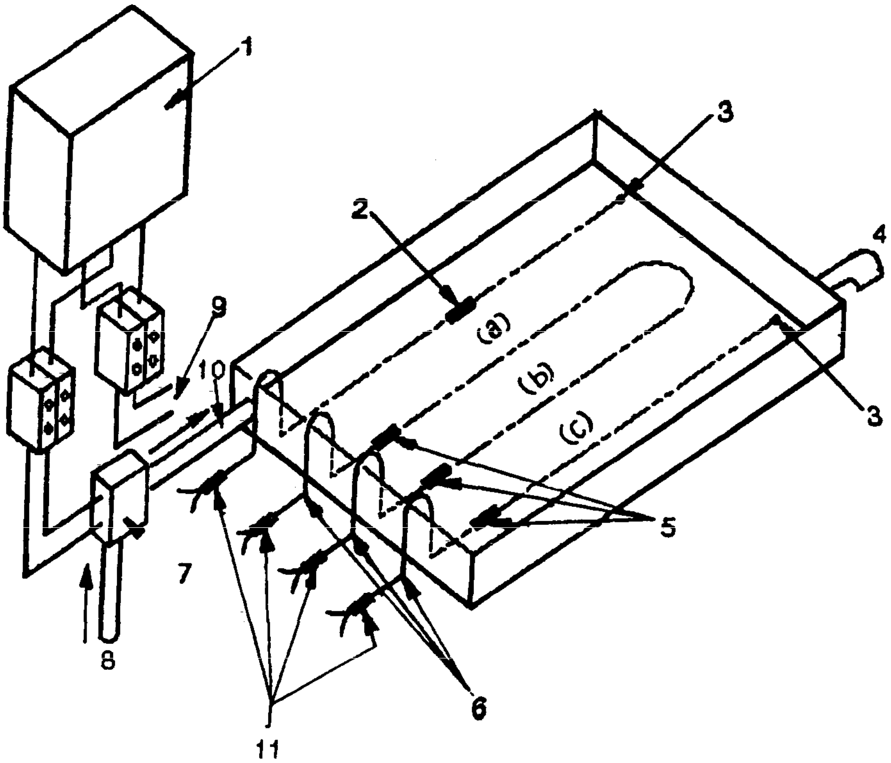
NOTE — In potentially explosive atmospheres it is critical to ensure that the maximum sheath temperature for trace heaters is less than the ignition temperature of the explosive mixture. The maximum sheath temperature is dependent on the heater power density, overall heat transfer coefficient, and the maximum possible excursion temperature of the surface to be heated. These factors are used by the manufacturer to determine the sheath temperature of the trace heaters.

Maximum sheath temperatures of trace heaters shall be determined to ensure the safe use of the heater(s). These sheath temperatures shall not exceed the temperature class, the maximum exposure temperatures of the workpiece material, the trace heater material and the thermal insulation.

The maximum allowable power density and sheath temperatures declared by the manufacturer shall be tested by one of the following two methods:

a) A system approach (*see* **5.1.11.2**), used to validate a manufacturer's design methodology and calculations, in which the trace heater is subjected to a test condition where the manufacturer demonstrates ability to design and predict sheath temperatures by conducting specific tests.

b) A product classification (*see* **5.1.11.3**), approach in which the maximum sheath temperatures are generated in an artificial environment simulating worst case conditions.



a) Parallel cable
b) Series cable, one conductor
c) Series cable, two conductors

1 Cam switch
2 *n*-line tee or slice connection (low profile)
3 End termination (low profile)
4 Drain
5 Power connection (low profile)
6 Cold lead
7 Solenoid valve
8 Water inlet
9 To heaters
10 Water outlet
11 Power connection (high profile)

FIG. 4 MOISTURE RESISTANCE TEST

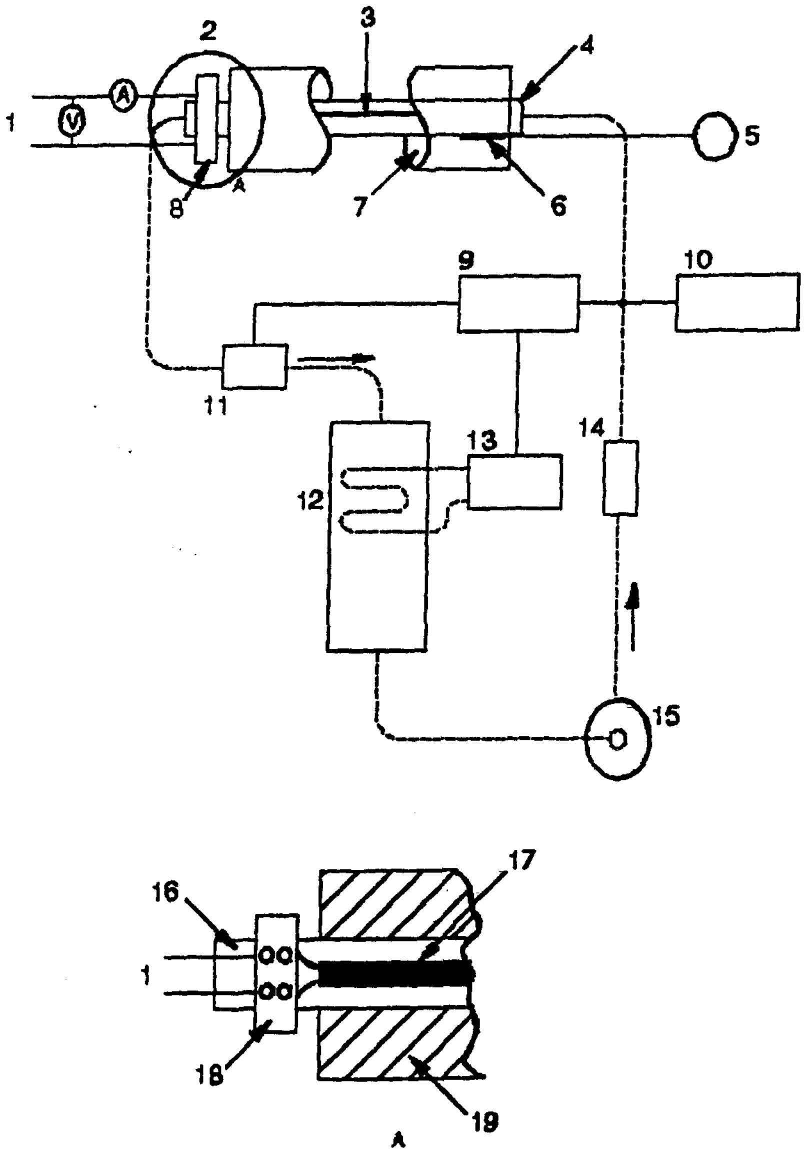
5.1.11.2 *Systems approach, design verification method*

a) For heating cables, the test apparatus (*see* Fig. 6) shall consist of a 3 m horizontal run and a 1.5 m vertical run of piping having a pipe size between 50 mm and 150 mm diameter. A flanged gate valve or equivalent (butterfly valve, globe valve etc) shall be located in the centre of the horizontal run. The vertical run shall be so arranged that the flanged pipe ends in the centre. The heating cable shall be installed in a manner consistent with the manufacturer's installation instruction. Thermocouples shall be used to monitor the pipe and valve surface temperatures and the trace sheath temperatures. The thermocouples shall be located at anticipated hot spots at the discretion of the testing station.

The piping system shall be insulated with a minimum of 25 mm thickness of thermal insulation and installed in accordance with the manufacturer's installation procedures. Pipe ends shall be plugged and thermally insulated. Unless a higher temperature is specified, the ambient temperature shall not exceed 40°C. The trace heater shall be powered at 110 percent of its rated voltage. System temperatures shall be allowed and stabilized and thermocouple readings recorded. The measured sheath temperatures shall not exceed manufacturer's calculated valves by more than 10K.

NOTE — This procedure shall be repeated with three variations of parameters, such as thermal insulation type and thickness.

b) For pads, panels and other surface heaters, a representative section shall be applied to a 6 mm steel plate in accordance with the manufacturer's instructions. The steel plate shall not extend more than 25 mm from any edge of the surface heater. The thermocouples shall be located at any anticipated hotspots at the

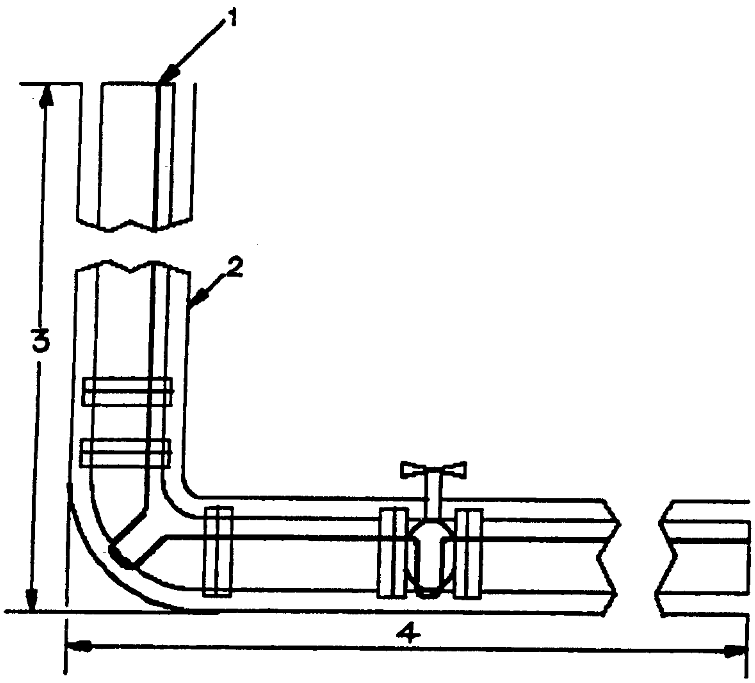


1	Controlled voltage source	11	In-line heater
2	*See* detail *A*	12	Heat exchanger
3	Test specimen	13	Chilling unit
4	50 mm on pipe	14	Flow meter
5	Temperature indicator	15	Pump
6	Thermocouple	16	Test pipe
7	25 mm fibre glass insulation	17	Heat tracing strip test specimen
8	Electric terminals	18	Thermal block
9	Temperature controller	19	Fibre glass insulation
10	Temperature sensor		

FIG. 5 VERIFICATION OF RATED OUTPUT : TYPE TEST

discretion of the testing station. The heated side of the plate shall be insulated with a minimum of 25 mm of thermal insulation. The plate is then located in a stable room temperature environment in a vertical orientation. The surface heater shall be powered at 110 percent of rated voltage. After stabilization the thermocouple readings shall be recorded including ambient temperature. The measured surface temperatures shall not exceed manufacturer's calculated values by more than 10 K.

NOTE — This procedure shall be repeated with three variations of parameters, such as thermal insulation type and thickness.

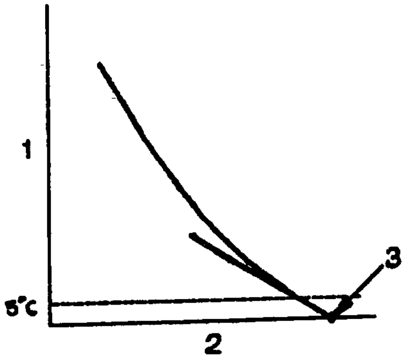


1 2-6 in NPT
2 Insulation fibre glass, 2.54 mm *Min*, 3.25 kg
3 1.5 m
4 3 m

FIG. 6 VERIFICATION OF SHEATH TEMPERATURE USING SYSTEM APPROACH

5.1.11.3 *Product classification approach*

A sample of heating cable at least 1.5 m in length is placed loosely coiled in a forced air circulation oven. The sample shall be within the upper half of the trace heater's thermal output tolerance. Representative thermocouples shall be used to monitor sample sheath temperatures and shall be placed 500 mm from each end. One additional thermocouple is used to monitor the temperature within the oven. The trace heater shall be energized at 110 percent of rated voltage. The oven ambient temperature shall be raised from ambient temperature in 15°C increments. Sufficient time shall be permitted at each temperature to allow for the oven temperature and the trace heater sheath temperature to stabilize and attain thermal equilibrium. Oven and heater sheath temperatures shall be recorded at each successive level until the difference (ΔT) between the two is 5 K or less. A curve shall be drawn from the test data, and a straight line drawn tangentially to the curve at 5 K temperature difference point and extended to 0 K. The temperature reading at this intercept shall be taken as the maximum sheath temperature, as shown in Fig. 7.



1 Sample temperature minus oven air temperature (*Ts* – *To*)°C
2 Oven temperature (*To*)°C
3 Recorded value of *Ts*

FIG. 7 MAXIMUM SHEATH TEMPERATURE USING THE PRODUCT CLASSIFICATION APPROACH

5.1.12 *Verification of Start-Up Current*

The start-up current of the trace heater shall be measured as a function of the manufacturer's minimum designated ambient temperature. A sample of heating cable at least 1 m in length shall be installed in accordance with the manufacturer's instructions on a minimum 50 mm diameter liquid-filled steel pipe or solid rod, or for heating panels or pads a flat metal heat sink. The testing apparatus shall be completely covered with thermal insulation and conditioned at the test temperature for at least 4 h.

NOTE — The apparatus described in **5.1.9** can be used for this test.

After the conditioning period, rated voltage shall be applied and the time/rms current characteristic shall be recorded from time 0 to 300 s. The start-up current recorded shall be the highest current response of three samples. The time-current characteristic shall not be more than the value declared by the manufacturer.

5.1.13 *Verification of the Resistance of Metallic Covering*

The resistance of the mechanical covering of at least 3 m length of trace heater shall be measured at 10 to 40°C. A representative sample of a heating panel or pad shall be used. The resistance shall be equal to or less than the manufacturer's declared value.

5.1.14 *Elevated Temperature Exposure Dielectric Test*

A sample of heating device shall be placed in a forced circulation air oven. The oven shall be heated to and maintained at a temperature of 25 ± 5°C above the highest exposure temperature declared by the manufacturer for a period of 14 days. The sample shall be removed from the air oven and cooled to room temperature. Heating cable samples shall be wound six close turns around a mandrel having a radius equal to twelve times the radius of the primary bending plane or thickness of the heating cable. Surface heating units, if flexible, shall be wrapped on a mandrel with a radius equivalent to the manufacturer's minimum recommended bending radius. While still on the mandrel the sample, except at terminations or ends where the conductor is exposed shall be submerged in tap water at 10 to 25°C for 5 min. While still in the tap water the dielectric test shall be performed. Rigid heating devices shall also be submerged in tap water and tested. Upon completion of the test, the sample shall have no visible cracks when examined with normal vision.

5.1.15 *Service Life Performance Bench Mark*

Three randomly selected samples representing the maximum output of all cables or surface heating device under evaluation shall be tested. If the type of cable or surface heating device has different levels of rated voltages and wattages, then three samples each shall be selected that represent (1) the lowest rated voltage level and the maximum rated output, and (2) the maximum rated voltage and the minimum rated output.

Samples shall be terminated according to the manufacturer's specifications, such that a heating length of at least 0.6 m or representative surface device dimension is provided. The aging temperature of the test shall be the maximum declared to maintain temperature of the heating device. The samples shall be conditioned, while energized, at the aging temperature for 120 ± 24 h. The initial output of the samples is then to be determined, with the exceptions of sample length and number of test temperature points. For this case, the samples shall be evaluated at rated voltage and at the manufacturer's stated reference temperature for the rated output. The output shall be within the manufacturer's stated output range.

The samples shall be attached to a fixture or suitable heat sink and insulated accordingly. The pipe or heat sink temperature shall be set to the specified aging temperature and maintained with ± 3°C plus 1 percent of the temperature reading in degrees Celsius. Circulating fluid or external heating may be used to raise the fixture to the aging temperature. The samples shall be operated at rated output for series cables or rated voltage for parallel cable. Surface heating devices shall be operated at rated output. The power supply shall be attached to a 15 min cycle timer such that the samples are energized for 12 min and de-energized for 3 min. The samples shall be exposed to this conditioning for 32 weeks (5 376 h).

For heating devices with an intermitent temperature exposure rating, the samples are exposed to the same conditioning for 32 weeks, except for an 8 h excursion once each week. At the beginning of the 8 h, the samples shall be disengaged from the cycle timer. The pipe or heat sink temperature shall be increased to a temperature equal to the manufacturer's stated intermittent exposure temperature. The time allowed to increase the temperature should be not greater than 1 h. After 7 h from the beginning of the excursion, the pipe or heat sink temperature shall be decreased back to the aging temperature again allowing no more than 1 h for the operation. Where the intermittent temperature rating is based on the heating device being energized, the heating device shall be continuously energized during this temperature excursion, except during cool down back to the maximum maintained temperature. Where the intermittent temperature rating is based on the heating device being de-energized, the exposure cycle is conducted in a de-energized condition. At the end of the 8 h excursion, the samples shall be re-engaged to the cycle timer. The excursion should occur on the same day each week.

At the end of the 32 weeks of operation at the continuous rated temperature, the output of the samples shall be determined by the same procedure as utilized for the initial readings. The percent change to the initial output shall be calculated. The heating cable or surface heating device shall not show an increase of more than 20 percent output; and the heating cable or surface heating device shall maintain a minimum of 75percent of the initial output.

5.2 Routine Tests

NOTE — These tests to be carried out after production or prior to shipment.

5.2.1 *Dielectric Test*

Each shipped length or item, whether in bulk or individually fabricated items, shall be subjected to the dielectric test specified in **5.1.2**.

The sheath (overjacket) used for corrosion resistance over the metallic braiding or continuous metallic covering shall either be subjected to the dielectric test of 1 000 V ac, whilst immersed in water, or to a dry spark test using a minimum voltage of 3 000 V ac.

As an alternative to immersing in water, the electrical insulation of trace heaters may be subjected to a dry spark test,with a minimum test voltage of 6 000 V ac rms that has a substantially sinusoidal wave form at 2 500 to 3 500 Hz. For a 3 000 Hz supply, the rate of travel of the trace heater through the dry test device, in metres per second, shall not be more than 3.3 times the length of the electrode in centimetres.

5.2.2 *Verification of Rated Output*

The output rating for each manufactured length of parallel heating cable shall be verified for linearity of power output through continuous or statistical test methods. The power output rating for each length of series resistance heating cable or fixed resistive heater shall be verified by measurement of the dc resistance, conductance or current at a given temperature. The test measurement criteria shall be established or correlate to the output verification test specified in **5.1.9**. If statistical methods are used the results shall represent a total product reliability of 95 percent or greater. The power output shall be within manufacturer's declared tolerances.

6 MARKING

6.1 General

All components of trace heating system, including the branch circuit protection device, monitoring instrumentation and temperature controllers, shall be suitably and permanently marked with relevant reference to the manufacturer's documents, model or catalogue numbers, approvals, certification and process requirements.

6.2 Factory Fabricated Trace Heater Units or Sets

Trace heaters with factory fabricated terminations shall have a durable tag/label permanently affixed to the non-heating sheath within 75 mm of the power connection fitting or gland, marked with the following:

a) The operating voltage;

b) The rated steady state current; and

c) The statement "Bond the metal sheath/braid of this trace heater to a suitable earth/ground terminal".

6.3 Bulk Heater Cables

Trace heaters certified to be field assembled into finished cable sets or units at the work site shall be clearly and permanently marked with the following:

a) The rated or operating voltage;

b) The rated power output or resistance per unit length (at a reference temperature); and

c) The statement "Bond the metal sheath/braid of this trace heater to a suitable earth/ground terminal".

6.4 Cable Spools, Reels or Cartons

The spool, reel or carton in or on which the bulk trace heater cable is delivered shall be marked with the following:

a) The rated or operating voltage;

b) The rated power output or resistance per unit length (at a reference temperature);

c) The statement "Bond the metal sheath/braid of this trace heater to a suitable earth/ground terminal"; and

d) The statement "refer to installation instructions".

6.5 Heater Field Termination/Splice Kits

The kit packaging shall be approved, listed or certified, and marked with the following:

a) The intended use (s) of the kit, for instance power termination;

b) The statement "refer to installation instructions".

c) The statement "Bond the metal sheath/braid of this trace heater to a suitable earth/ground terminal"; and

d) The presence of electrically heated pipelines or vessels, or both, shall be evident by the posting of appropriate caution signs or markings at frequent intervals along the pipeline or vessel.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
2148 : 1981	Flameproof enclosures for electrical apparatus (*second revision*)
5571 : 1979	Guide for selection of electrical equipment for hazardous areas
6381 : 1972	Construction and testing of electrical apparatus with type of protection 'e'
13408 (Part 1) : 1992	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining application or explosive processing manufacture) : Part 1 General recommendations
13346 : 1992	General requirements for electrical apparatus for explosive gas atmospheres
14614 : 1998	Residual current operated protective devices (RCDs) for household and similar use-electrotechnical compatibility

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'.

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Amendments Issued Since Publication

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